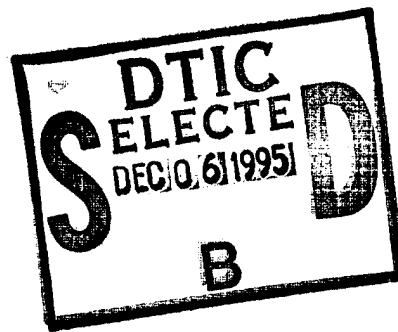
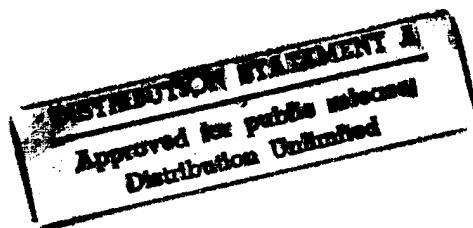

Logistics Management Institute

World Defense Trade Prospects

EC404RD1



Lawrence Schwartz
Earl R. Wingrove III



19951205 059

LMI

REPORT DOCUMENTATION PAGE

*Form Approved
OPM No.0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources gathering, and maintaining the data needed, and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

1. AGENCY USE ONLY (Leave Blank)			2. REPORT DATE June 1994		3. REPORT TYPE AND DATES COVERED Final		
4. TITLE AND SUBTITLE World Defense Trade Prospects					5. FUNDING NUMBERS C MDA903-90-C-0006 PE 0902198D		
6. AUTHOR(S) Lawrence Schwartz, Earl R. Wingrove III							
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Logistics Management Institute 2000 Corporate Ridge McLean, VA 22102-7805					8. PERFORMING ORGANIZATION REPORT NUMBER LMI- EC404RD1		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Deputy Assistant Secretary of Defense for Production Resources The Pentagon, Room 3C263 Washington, D.C.					10. SPONSORING/MONITORING AGENCY REPORT NUMBER		
11. SUPPLEMENTARY NOTES							
12a. DISTRIBUTION/AVAILABILITY STATEMENT A: Approved for public release; distribution unlimited					12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words) The Office of the Deputy Assistant Secretary of Defense for Production Resources [(DASD(PR)] requested that the Logistics Management Institute (LMI) project world defense trade from 1994 through the year 2000. DASD(PR) provided LMI with a data base on arms trade and potential economic and financial explanatory variables for 138 countries over the 1981-1991 period. The authors applied pooled cross-section and time series econometric techniques to test various international trade models. Arms trade is explained very well by contemporaneous and lagged military expenditures and the presence or absence of a cold war environment. Utilizing that model, various military activity scenarios are specified to provide a range of arms trade projections for the Middle East, East Asia, and the rest of the world. The implications for the U.S. defense industrial base are also discussed.							
14. SUBJECT TERMS Arms trade; U.S. defense industrial base; Middle East arms imports; East Asia arms imports; cold war; post-cold war; U.S. Arms Control and Disarmament Agency					15. NUMBER OF PAGES 17		
					16. PRICE CODE		
17. SECURITY CLASSIFICATION OF REPORT Unclassified		18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified		19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified		20. LIMITATION OF ABSTRACT UL	

June 1994

World Defense Trade Prospects

EC404RD1

Lawrence Schwartz
Earl R. Wingrove III

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By Distribution/	
Availability Codes	
Distr	Avail and/or Special
W	

DTIC QUALITY INSPECTED 

Prepared pursuant to Department of Defense Contract MDA903-90-C-0006. The views expressed here are those of the Logistics Management Institute at the time of issue but not necessarily those of the Department of Defense. Permission to quote or reproduce any part except for government purposes must be obtained from the Logistics Management Institute.

Logistics Management Institute
2000 Corporate Ridge
McLean, Virginia 22102-7805

Preface

The Office of the Deputy Assistant Secretary of Defense for Production Resources [DASD(PR)] is undertaking a complete examination of defense trade policy. Arms trade prospects are an important part of that review. Pursuant to that review, DASD(PR) requested that the Logistics Management Institute (LMI) rapidly analyze, project, and explain world defense trade from 1994 through the year 2000. Also, separate arms trade forecasts and explanations are required for the Middle East and for East Asia.

DASD(PR) provided LMI with data on more than 40 defense trade, economic, and financial variables covering 138 countries over the 1981-1991 period. Working with that detailed data base, we employed econometric techniques to explain arms trade and developed alternative scenarios to provide a range of projections. This research document benefited greatly from discussions with Jay Mandelbaum, Production Base Division, DASD(PR).

Executive Summary

World defense trade has plummeted as the United States and the former Soviet Union have reduced their military expenditures significantly, beginning in 1989. By 1991, the last year of actual data, annual world arms imports stood at \$25.6 billion — down by more than half from the \$53 billion level (in constant 1991 dollars) recorded in 1989. We estimate that 1993 world arms imports further declined to \$18.7 billion in constant 1991 dollars. Two major questions emerge from this trend: What will happen to the world defense trade market by the year 2000? And can the United States rely on the world defense trade market to help maintain its defense industrial base?

We developed an econometric model showing that arms imports depend upon contemporaneous and lagged military expenditures and upon the presence or absence of a cold war environment. That model explains 86 percent of the variation in arms imports across 138 countries over the 1982 – 1991 period. When aggregated to worldwide totals, the model can be used to estimate arms imports with a 9-percent absolute error rate and to track changes in direction over the 1982 – 1991 period very well.

We considered two divergent forecasting scenarios. The upper bound forecasting scenario assumes a 3-percent annual increase in real military expenditures and a return to a cold war environment or its equivalent beginning in 1994. The lower bound forecasting scenario assumes a 1-percent annual decline in real military expenditures, which would be consistent with a continuation of the 1989 – 1991 post-cold war environment. We draw a likely forecast from these two limiting scenarios.

We forecast that annual world arms sales could total \$25 billion (in constant 1991) dollars by the year 2000. The Middle East could import as much as \$15 billion by the year 2000, a return to its 1989 level. East Asia may very well achieve a \$6 billion or even higher arms import level by the year 2000. And the rest of the world could account for as little as \$4 billion in arms imports by the year 2000.

United States arms exports could reach \$10 billion in the year 2000 by maintaining a 40-percent share (1991 rate) of the likely world market. The \$10 billion level of U.S. arms exports would be no higher than that achieved in 1991, well below the \$17 billion peak of 1987. This being the likely case, the U.S. defense industrial base cannot count on the world defense trade market for significant additional support.

Contents

Preface	ii
Executive Summary	iii
Chapter 1. Introduction	1
Chapter 2. Arms Trade Relationships	3
Chapter 3. Arms Trade Projections	7
Middle East	7
East Asia	8
Rest of the World	9
World and U.S. Implications	10
U.S. Arms Exports	11
Appendix. Econometric Analysis of Arms Trade	

CHAPTER 1

Introduction

Arms trade was quite steady for most of the 1980s but has been dropping since 1989. During the 1986 – 1988 period, for example, annual world arms exports averaged \$63 billion in constant 1991 dollars (or in real terms). In contrast, annual world arms exports, in real terms, averaged \$39.3 billion during the 1989 – 1991 period — a drop of 24.8 percent (see Table 1).

Table 1.
World and U.S. Defense Trade, 1986 – 1991

Defense exports	Year						Average		
	1986	1987	1988	1989	1990	1991	1986 – 1988	1989 – 1991	1986 – 1991
Constant 1991 dollars (billions)									
World	60.4	67.9	60.8	53.8	39.3	25.2	63.0	39.3	51.2
U.S.	11.1	16.7	12.9	14.6	10.3	9.6	13.6	11.5	12.5
U.S. share (percent)	18.4	24.6	21.2	27.1	26.2	38.1	21.4	30.4	25.9
Constant dollar growth (annual percent changes)									
World	-3.1	12.4	-10.5	-11.5	-27.0	-35.9	-0.4	-24.8	-12.6
U.S.	-20.1	50.5	-22.8	13.2	-29.5	-6.8	2.5	-7.7	-2.6
U.S. share	-16.7	33.7	-13.8	27.8	-3.3	45.4	1.1	23.3	12.2

Note: At present, no defense trade data are available beyond 1991.

The U.S. arms trade declined more slowly. Real U.S. arms exports fell by only 7.7 percent between the 1986 – 1988 period (when they averaged \$13.6 billion) and the 1989-1991 period (averaging \$11.5 billion). As a result, the U.S. market share of world exports actually rose — from 21.4 percent during the 1986 – 1988 period to 30.4 percent during the 1989 – 1991 period. Nevertheless, the U.S. defense industrial base in the 1989 – 1991 period was being not supported nearly as much by the world defense trade market as it had been earlier.

Leading arms importers are concentrated in the Middle East and East Asia. For example, in 1991, Saudi Arabia, Iran, Syria, and Israel accounted for \$9.6 billion or about 38 percent of world defense trade. In East Asia, Japan, South Korea, Thailand, China-Taiwan, and China-Mainland accounted for \$2.4 billion or almost 10 percent of 1991 world defense trade. Thus, a relatively few countries

in the Middle East and East Asia accounted for almost half of 1991 world defense trade. The remaining half of 1991 arms imports was highly dispersed among 129 other importing countries.

This research document focuses on three basic questions: What are the prospects for world defense trade between 1994 and 2000? How does the propensity to import arms differ among the countries of the Middle East, those in East Asia, and those in the rest of the world? And what are the implications of these world defense market trends for U.S. arms exports?

Chapter 2 discusses the econometric arms trade relationships that we developed for explaining and forecasting regional and world defense trade between the years of 1994 and 2000.

Chapter 3 presents defense trade forecasts for the Middle East, East Asia, and the rest of the world. It also discusses the defense trade prospects for the United States.

The appendix outlines the major technical underpinnings of the econometric arms trade relationships presented in Chapter 2.

CHAPTER 2

Arms Trade Relationships

We have chosen to examine world trade relationships from the perspective of the importing country, rather than from the viewpoint of the exporting country. We also have chosen to use econometric techniques on the detailed data provided to us — for 138 countries over the 1981 – 1991 period — rather than dealing with regional data aggregates for each year. We have three reasons for doing so. First, econometrically, it has been more tractable to explain the demand for imports than it is to explain the supply of exports. Second, the detailed data provide much greater variation than do the regional aggregations, and that is desirable for econometric testing. Third, a country's import levels do not necessarily agree with the exports to that country as recorded, and we prefer the import data, because customs services focus especially on imports, given their special importance to national security and import duties and for other reasons.

The econometric literature on international trade provides two different theories for explaining imports. For a developed country, the traditional explanation of import demand is the level of its economic activity and the ratio of domestic prices to import prices. As this theory goes, import demand becomes higher as the country's level of economic activity increases and as its domestic prices rise relative to those of potential trading partners. For a less developed country, a different explanation has often been offered: the availability of foreign currency and the ability to pay. According to this theory, import demand for a less developed country is constrained by its accumulation of foreign currency from its export earnings, grants-in-aid, loans, and foreign direct investment.

We have tested these two basic models for examining arms imports. We found that the level of arms imports depends on the level of present and past military expenditures as well as on the presence or absence of a cold war environment. We found no statistical evidence that arms imports depend upon currency or relative price considerations. We did find significantly different regional defense trade relationships for the Middle East, East Asia, and the rest of the world.

Table 2 presents the arms import demand coefficients for the Middle East, East Asia, and the rest of the world. As explained in the appendix, these regional trade relationships were estimated simultaneously by pooling data for 138 countries in the 1982 – 1991 time frame (1981 data were used for lagging purposes only). Also as presented in the appendix, a Koyck lagged formulation was utilized to estimate the lagged effects of military expenditures on arms imports. The model explains 86 percent of the variation in arms imports across the 138 countries and 10 years (1380 observations), a result that provides high explanatory power.

Table 2.
Arms Import Demand Relationships by Region

Region	Military expenditures		Cold war effect (millions of constant 1991 dollars)
	Arms import propensity	Lagged weighting factor	
Middle East	0.0795	0.7123	17,574
East Asia	0.0017	0.8647	12,772
Rest of the world	0.0007	0.8382	47,565

Source: Appendix.

Notes: The Middle East region consists of 16 countries, including Saudi Arabia, Israel, Iran, Iraq, and Syria; the East Asia region consists of 18 countries, including China-Mainland, China-Taiwan, Japan, North Korea, and South Korea; and the rest-of-the-world region consists of the remaining 104 countries, including those in Europe, North America, Latin America, Africa, South Asia, and Oceania. The military expenditure variable includes both contemporaneous and lagged levels. Contemporaneous military expenditures are given by the full amount spent in those years. Lagged military expenditures are given by partial amounts spent in those years, according to geometrically declining weighting factors: the first-period military expenditure lag is multiplied by the weighting factor itself, the second-period military expenditure lag is multiplied by the square of the weighting factor, etc. The cold war effect is the tendency of arms imports to be higher in the 1982-1988 cold war period as compared to the post-cold war period of 1989-1991, after taking into account military expenditure differences.

The Middle East is unique among the regions examined in its arms import relationships. The arms import propensity for the Middle East is almost 8 cents per defense dollar, significantly more than that for any other region. Also, if the Middle East spent \$65 billion on defense for 10 years running, each of those yearly expenditures would contribute something to arms imports for each succeeding year. In the final year, the constant \$65 billion stream of military expenditures would translate into \$18 billion worth of arms imports — 0.08 propensity to import multiplied by contemporaneous and lagged weighted military expenditures, which is given by: $65 + 0.71(65) + 0.71^2(65) + \dots + 0.71^{10}(65)$.¹ Aside from military expenditures, arms imports tended to be more than \$17 billion higher in the 1982 – 1988 cold-war period than in the 1989 – 1991 post-cold war period.

The arms import relationship for East Asia differs from that for the Middle East substantially. East Asia's import propensity is relatively low — only about 0.2 cents per military expenditure dollar. By the same method used in the Middle East case, we can calculate the effect of a steady stream of East Asia defense expenditures on arms imports in the final year. For example, if each year East Asia spent \$100 billion in real terms steadily over two decades, that commitment would translate into only about \$1.1 billion of real arms imports in the final year.² Finally, aside from the effects of military expenditures, East Asian arms

¹ The formula for the sum of an infinite converging series can also be used to calculate the effect of a steady stream of military expenditures on arms imports. In this example, the sum of the series is given by \$65 billion divided by (1-0.71), or \$224 billion of current and past military expenditures potentially relevant for arms imports.

² Lagged military expenditures significantly affect East Asia and rest-of-the-world arms imports for approximately twice as long a period as they do those of Middle East. For this reason, in the examples, we consider military expenditures over two decades for East Asia and the rest of the world as compared to one decade for the Middle East.

imports tended to be more than \$12 billion higher in the 1982 – 1988 cold-war period than they were in the 1989 – 1991 post-cold war period.

The results for the rest-of-the-world region are similar to those for East Asia. The rest of the world's propensity to import arms is the lowest of all for the regions examined — less than 0.1 cents per dollar of military expenditures. Also, if the rest-of-the-world region steadily spent \$800 billion (in real terms) annually on defense over two decades, that commitment would translate into only about \$3.5 billion of arms imports in the final year. Finally, aside from the effects of military expenditures, the rest-of-the-world arms imports tended to be more than \$47 billion higher in the 1982 – 1988 cold war period than in the 1989 – 1991 post-cold war period.

We also tested how well these defense trade relationships yielded arms import estimates for the years from 1982 through 1991. Because of our interest in projecting regional arms imports, rather than in forecasting individual countries' arms imports, we aggregated the country-specific estimates to regional estimates for each year. Actual and estimated world arms imports are derived from the sum of the regional totals. Table 3 summarizes the average estimating error rates for each region over the 1982 – 1991 period.

Table 3.
Average Estimating Error Rates

Region	Estimating error rate (in absolute terms)	
	Billions of constant 1991 dollars	Percent
World	4.8	9.3
Middle East	3.1	15.1
East Asia	0.5	7.2
Rest of the world	2.1	9.1

Note that the average error rates are expressed in absolute values to provide a more meaningful picture of error range.³ For world arms imports, the model showed a 9.3- percent average absolute estimating error rate. The estimating error rates for East Asia and the rest of the world are somewhat below the world absolute error rates, while the absolute average error rate for the Middle East is about 15 percent. Equally important, the arms import estimates for each region tracked the precipitous defense trade declines that began in 1989 very well.

³The simple average estimating error rate—as opposed to the absolute average estimating error rate—could offset relatively high negative error rates with relatively positive ones, thereby giving the appearance of a much better estimating performance than is justified. For example, the simple world arms import estimating error rate is 1.6 percent, while the absolute world arms estimating error rate is 9.3 percent. The simple estimating error rate is lower, in part, because of a minus 11.9-percent error rate in 1987 offsetting a plus 12-percent error rate in 1985.

Figure 1 displays the estimated and actual world arms imports from 1982 through 1991.

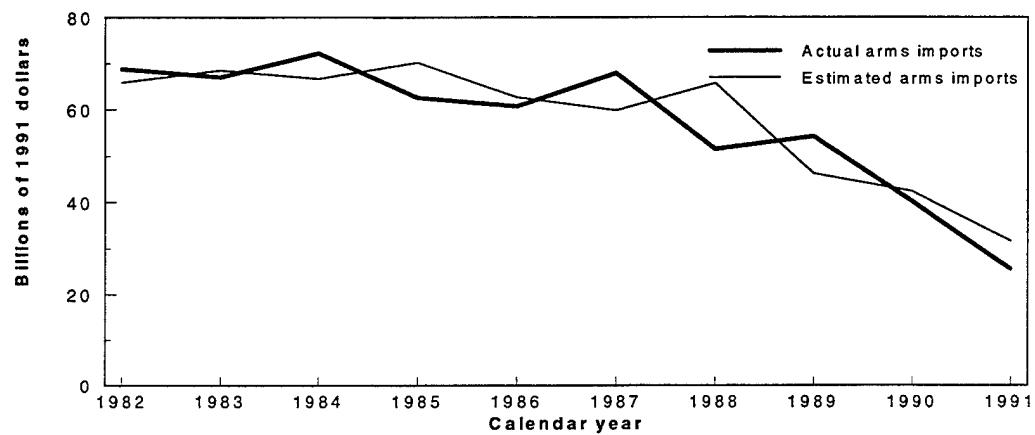


Figure 1.
Worldwide Arms Imports: Actual Versus Estimated

CHAPTER 3

Arms Trade Projections

In this chapter, we project arms imports for the Middle East, East Asia, the rest of the world, and the world as a whole from 1994 through the year 2000. The projection equations were developed with data through 1991 only. As a result, we first need to make historical projections — covering 1992 and 1993 — before we can make future projections.

We developed two forecasting scenarios for each region: (1) an upper bound forecast based upon a return to cold war conditions or their equivalent in 1994 and a 3-percent annual increase in real military expenditures (a worldwide rate achieved in the early 1980s), and (2) a lower bound forecast based upon a continuation of 1989 – 1991 post-cold war conditions and a 1-percent annual reduction in real military expenditures. Worldwide reductions in real military expenditures were more than 2 percent per year in the 1989 – 1991 period, but we did not choose that rate of decline for the lower bound scenario because we did not believe it was sustainable over the long run. We use these two basic scenarios for each region, including the Middle East which has had huge swings in real military expenditures in the 1982 – 1991 period.

We have chosen to take uncertainty into account by developing two widely divergent forecasting scenarios, rather than by projecting point estimates and showing statistical upper and lower confidence limits around those point estimates. We believe that the resultant forecasting band is appropriate for projecting arms imports through the year 2000.

MIDDLE EAST

Figure 2 presents upper and lower bound forecasts for Middle East arms imports. The upper bound forecasting scenario assumes a return to the cold war environment — adding \$17 billion in real terms between 1994 and the year 2000 from post-cold war levels — and a 3 percent annual growth rate in real military expenditures from 1994 through 2000. The lower bound forecasting scenario assumes a continuation of the 1989 – 1991 post-cold war environment and a 1-percent decline in real military expenditures for each year from 1992 through 2000. Note that the lower bound scenario is used to project Middle East arms imports for 1992 and 1993 because it most closely coincides with actual events.

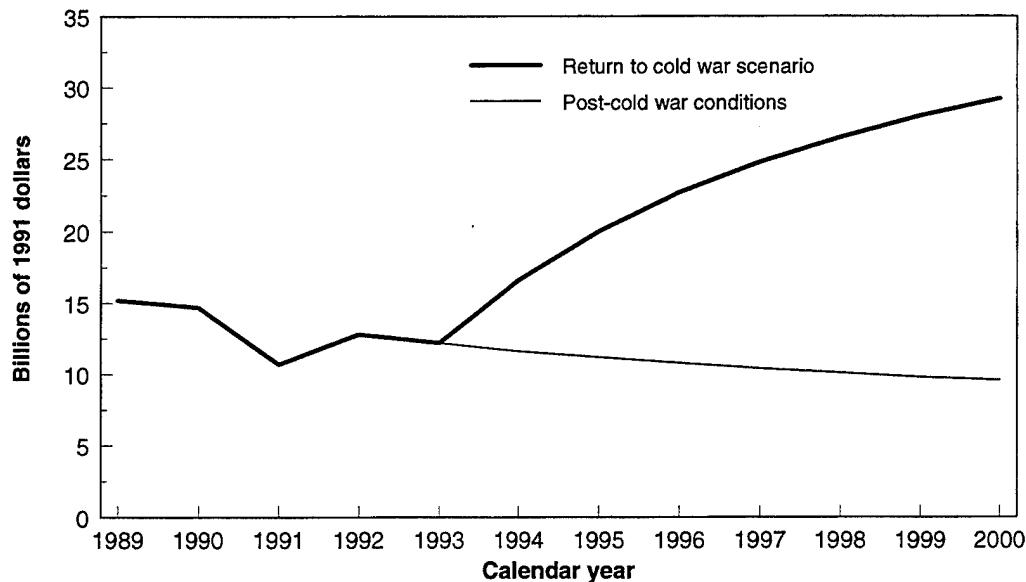


Figure 2.
Middle East Arms Imports

Under continued post-cold war conditions, the annual arms import projections for the Middle East show a decline from a \$15 billion level in 1989 to \$10 billion by the year 2000. In contrast, a return to a cold war environment or its equivalent could increase Middle East real arms imports to more than \$29 billion annually by the year 2000. Middle East security questions undoubtedly will determine whether the region's annual arms imports are as little as \$10 billion or as much as \$29 billion in constant 1991 dollars by the year 2000. The Middle East's annual arms imports may very well reach the 1989 level of \$15 billion by the year 2000 as the region's military expenditures return to more normal levels at that time.

EAST ASIA

Figure 3 displays upper and lower bound forecasts for East Asia arms imports. The upper bound scenario assumes a return to the cold war environment and a 3-percent annual growth rate in real military expenditures from 1994 through 2000. The lower bound scenario assumes a continuation of the 1989 - 1991 post-cold war conditions and a 1-percent annual decline in real military expenditures for each year from 1992 through 2000. Note that the lower bound scenario is used to project East Asia arms imports for 1992 and 1993.

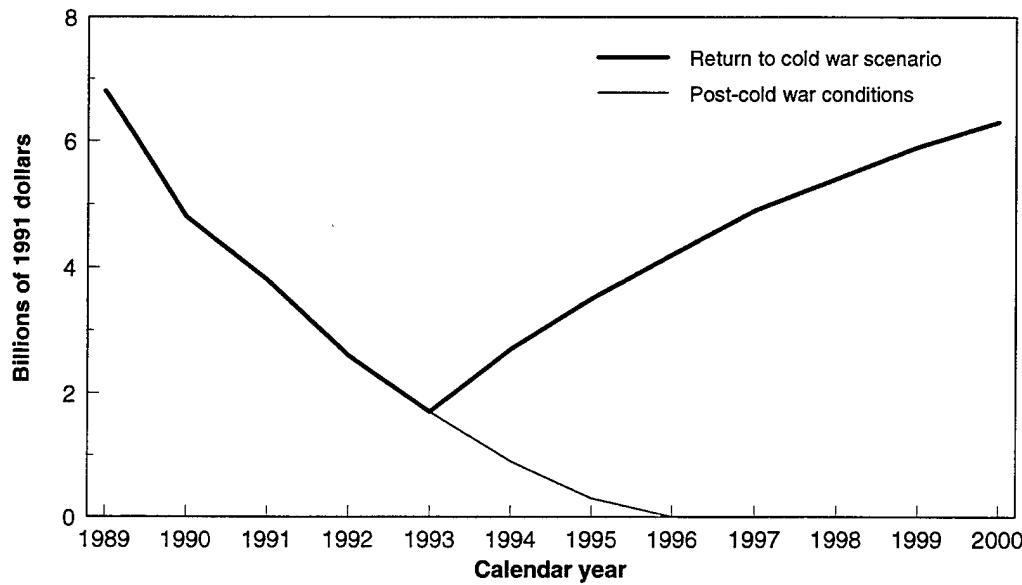


Figure 3.
East Asia Arms Imports

East Asia's arms imports could disappear by the year 1996 under 1989 – 1991 post-cold war conditions. In contrast, a resumption of the cold war environment could increase annual East Asian arms imports to about \$6.5 billion in real terms, almost restoring the level achieved in 1989. East Asia probably will represent an important world arms market by the year 2000, equaling or perhaps exceeding the upper bound forecasts. For example, South Korea hopes to offset North Korea's numerical advantage in weaponry, Taiwan is attempting to convince Western suppliers to sell it more weapons, and Australia is moving ahead with a frigate and submarine program to protect its northern and western approaches.⁴

REST OF THE WORLD

Figure 4 shows upper and lower bound projections for arms imports in the rest of the world. The upper bound scenario assumes a return to the cold war environment and a 3-percent annual growth rate in real military expenditures from 1994 through 2000. The lower bound scenario assumes 1989 – 1991 post-cold war conditions and a 1-percent annual decline in real military expenditures from 1992 through 2000. Note that the lower bound scenario is used to make projections for rest-of-the-world arms imports in 1992 and 1993.

⁴U.S. Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers 1991-1992*.

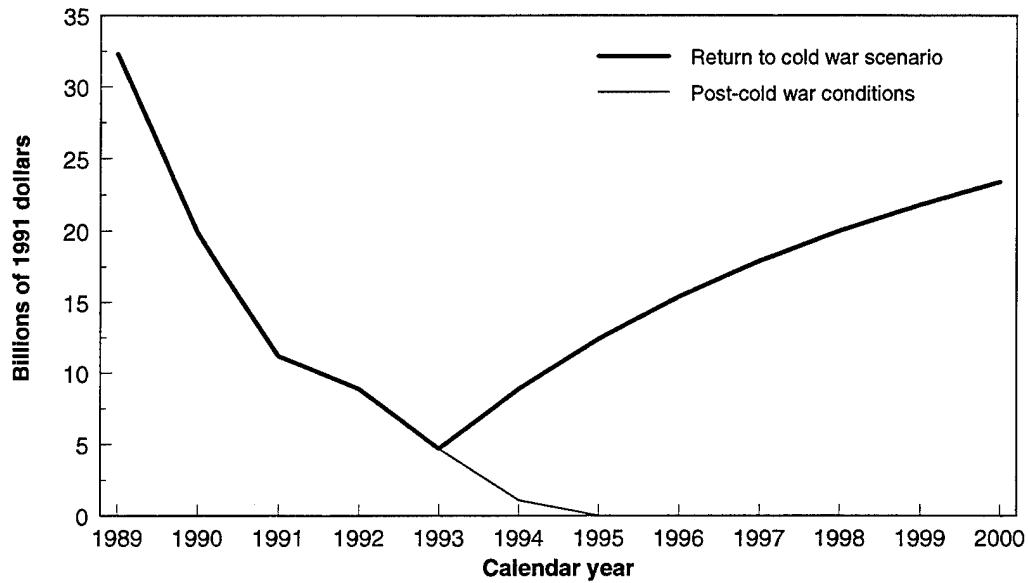


Figure 4.
Rest-of-the-World Arms Imports

The rest-of-the-world projections show that its 104 countries could import as much as \$23 billion in arms (in constant 1991 dollars) annually by the year 2000 under cold war conditions or their equivalent. In contrast, the rest of the world could import nothing by the year 1995 under continued post-cold war conditions. Defense-related shocks short of a full resumption of the cold war environment could require the rest of the world to import some arms through the year 2000, perhaps on the order of \$4 billion in real terms. Even if the rest-of-the-world arms imports did reach \$23 billion in real terms by the year 2000, that level would still fall short of the \$32 billion real expenditures posted in 1989.

WORLD AND U.S. IMPLICATIONS

Figure 5 displays upper and lower bound worldwide forecasts of arms imports. These world arms forecasts are summations of the regional arms import projections that have been presented for the Middle East, East Asia, and the rest of the world. The upper bound forecasting scenario embeds the effect of a return to the cold war environment and reflects a 3-percent annual growth rate in real military expenditures from 1994 through 2000. The lower bound forecasting scenario includes the effect of a continued post-cold war environment and a 1-percent annual decline in real military expenditures from 1992 through 2000. As in the case of the regional forecasts, 1992 – 1993 world arms import projections are based upon the lower bound scenario.

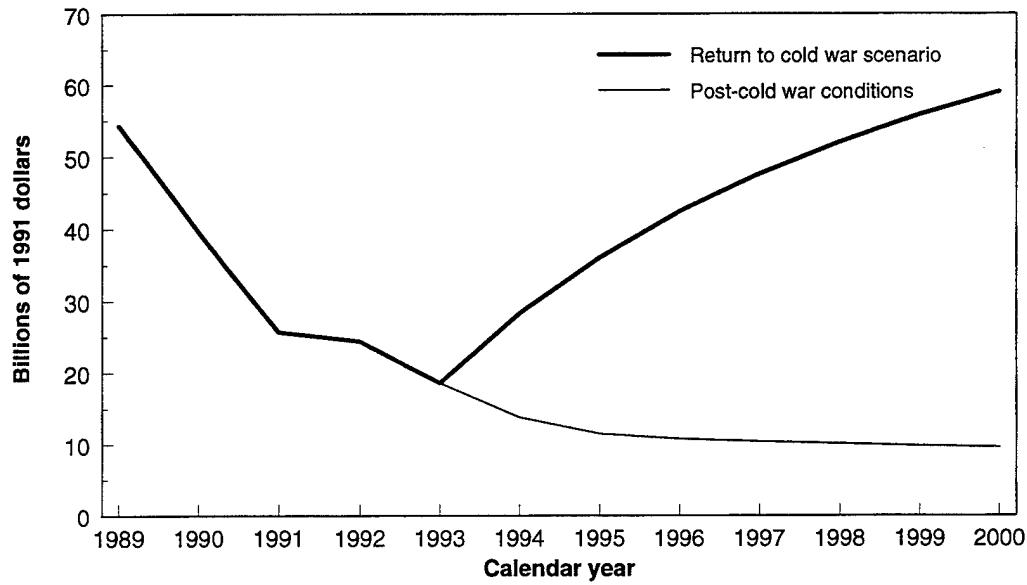


Figure 5.
Worldwide Arms Imports

World arms imports could level off in the year 2000 at as little as \$9 billion annually in constant 1991 dollars, continuing the precipitous decline begun in the 1989 – 1991 post-cold war period. In contrast, annual world arms imports could go as high as \$59 billion in real terms by the year 2000, assuming a return to the cold war scenario or its equivalent — a level last recorded in 1989 but still well below the \$73 billion peak posted in 1984. It is unlikely that the upper bound arms import projection will be reached by the year 2000, but some modest growth from the \$18 billion level (in constant 1991 dollars) estimated for 1993 seems likely — perhaps to as much as \$25 billion by the year 2000. According to the U.S. Arms Control and Disarmament Agency's 1991 – 1992 report, *World Military Expenditures and Arms Transfers*, modest growth in arms trade can be expected as "fighter aircraft and armored vehicles... will continue to comprise the bulk of the world market, [but] the major growth areas will be exports of sophisticated munitions and support equipment.... Major weapons will increase only marginally from currently depressed levels."

U.S. ARMS EXPORTS

What are the implications of the \$25 billion real world market for U.S. arms exports in the year 2000? Although we have not performed a detailed analysis of U.S. arms export share prospects, we consider three alternative U.S. export shares that are rooted in history: (1) the 21 percent recorded, on the average, during the 1986 – 1988 cold war period; (2) the 30 percent posted, on the average, during the 1989 – 1991 post-cold war period; and (3) the 38 percent that was achieved in 1991 (the last year of actual data). (Table 4 shows arms export shares

of the United States and other key countries for selected years.) Under the three alternatives, U.S. real arms exports in the year 2000 could be as little as \$5.3 billion (alternative 1), perhaps \$7.5 billion (alternative 2), or as high as \$10 billion (alternative 3).

Table 4.
Arms Export Shares of Key Countries, 1985, 1990, and 1991

Country	Shares (percent)		
	1985	1990	1991
Soviet Union	34.5	37.5	26.2
United States	22.0	26.2	38.2
France	14.0	10.0	4.4
United Kingdom	3.2	11.4	14.7
West Germany	2.8	2.6	5.2
Italy	2.4	0.3	0.3
China-Mainland	1.5	3.7	3.7

Notes: The world arms market declined in real terms throughout this period from \$62.3 billion in 1985, to \$39.3 billion in 1990, to \$25.2 billion in 1991. Arms export levels declined for all countries over this period, especially for the former Soviet Union. But U.S., United Kingdom, and West German arms exports fell relatively less, with their export shares rising over this period.

Even if the United States were to succeed in maintaining the relatively high arms export share of 38 percent (alternative 3), that would not help to support its defense industrial base beyond what was achieved in 1991. U.S. real arms exports were \$10 billion in 1991, the same level that would be achieved in the year 2000 with a U.S. export share of 38 percent. U.S. real arms exports were as high as \$17 billion in 1987, and it is unlikely that the U.S. arms exports would reach that level in the year 2000. In fact, the U.S. market share would have to reach an unlikely 68 percent of the \$25 billion world arms imports if the United States were again to reach 1987's peak level of \$17 billion.

APPENDIX

Econometric Analysis of Arms Trade

This appendix provides the major technical underpinnings for the results presented in this research document. Specifically, it covers the development of the general explanatory model, Koyck regression estimating equations, and regional projection equations.

GENERAL EXPLANATORY MODEL

Our explanatory model indicates that a country's arms imports depend upon contemporaneous and lagged military expenditures and upon the presence or absence of cold war conditions. Equation A-1 articulates this basic model (later we incorporate regional distinctions to fully specify the model):

$$ARMSIMP(it) = a(0) + a(1)CWD + b(0)ME(it) + b(1)ME(it-1) + b(2) \times ME(it-2) + b(3) \times ME(it-3) + \dots + e(it) \quad [\text{Eq. A-1}]$$

where

ARMSIMP	=	arms imports in millions of constant 1991 dollars
i	=	countries, i=1,2,...138
t	=	time periods, 1981-1991
CWD	=	1 if 1982-1988 cold war period 0 if 1989-1991 post-cold war period
ME	=	military expenditures in millions of constant 1991 dollars.

Equation A-1, however, cannot be estimated by ordinary least squares in its current form. The reason is that we are likely to encounter a high degree of multicollinearity among the military expenditure terms, which would have a detrimental effect on the military expenditure estimated coefficients and their standard errors. To overcome this problem of multicollinearity, restrictions usually are placed on the regression coefficients, $b(0), b(1), \dots, b(n)$, so that the number of the regression parameters becomes substantially reduced.

A number of formulations have been used to restrict the number of regression parameters. For example, the Almon lag formulation assumes that the "b" coefficients can be approximated by a polynomial function of a suitable degree, which generally reduces the number of military expenditure terms considerably. However, we cannot use this formulation, because the data do not provide enough time series experience. In contrast, the Koyck lag formulation

assumes an explicit form for the "b" coefficients: they decline geometrically according to $b(t)=b(0)r^t$, where $t=0,1,\dots,n$ and $0 < r < 1$. The "r" represents the rate of decline or decay of the effect of lagged military expenditures on arms imports.

Incorporating the Koyck lagged formulation— $b(t)=b(0)r^t$ —in Equation A-1, we obtain:

$$ARMSIMP(it) = a(0) + a(1)CWD + b(0)ME(it) + b(0)rME(it-1) \\ + b(0)r^2ME(it-2) + b(0)r^3ME(it-3) + \dots + e(it). \quad [\text{Eq. A-2}]$$

However, Equation A-2 still has numerous military expenditure terms. To reduce those military expenditure terms to a manageable number, the Koyck formulation takes three additional steps:

Step 1: Consider the lag of Equation A-2.

$$ARMSIMP(it-1) = a(0) + a(1)CWD + b(0)ME(it-1) \\ + b(0)rME(it-2) + b(0)r^2ME(it-3) \\ + b(0)r^3ME(it-3) + \dots + e(it-1). \quad [\text{Eq. A-3}]$$

Step 2: Multiply Equation A-3 by the "r" rate of decline.

$$ARMSIMP(it-1) = ra(0) + ra(1)CWD + b(0)rME(it-1) \\ + b(0)r^2ME(it-2) + b(0)r^3ME(it-3) \\ + \dots + re(it-1). \quad [\text{Eq. A-4}]$$

Step 3: Subtract Equation A-4 from Equation A-2 and rearrange terms.

$$ARMSIMP(it) = a(0)(1-r) + a(1)(1-r)CWD + b(0)ME(it) \\ + rARMSIMP(it-1) + (e(it) - re(it-1)). \quad [\text{Eq. A-5}]$$

Note that Equation A-5 yields the desired estimating equation: It contains only one military expenditure term (the current level), and it can help determine the coefficients in Equation A-1.

The estimating equation (Equation A-5) and the Koyck lag expression translate as follows into the explanatory coefficients in Equation A-1. The constants, $a(0)$ and $a(1)$, are obtained by dividing the Equation A-5 constants by $(1-r)$ —where r is obtained from the lagged arms import coefficient in Equation A-5. The estimated coefficient of the current military expenditure term in Equation A-5, $b(0)$, is the same as that in Equation A-1. And the lagged military expenditure coefficients in the explanatory equation are derived from the decaying Koyck lag expression: $b(t)=b(0)r^t$.

ESTIMATED AND PROJECTION EQUATIONS

We use Equation A-5 as the estimating equation. However, to make regional distinctions, we add "dummy" variables for each of three regions — the Middle East (MD), East Asia (EA), and the rest of the world (ROW). Equation A-6 presents our results. The regional intercept and slope terms were significant at the 1 percentage point of the F-distribution. The military expenditure and lagged arms import variables were both significantly different from zero at the 95-percent confidence level of the t-ratio. The "r" lagged arms import coefficient lies between zero and one, as required by the Koyck formulation: 0.7123 for the Middle East, 0.8382 for the rest of the world, and 0.8647 for East Asia. The equation explains 86 percent of the variation in arms imports over 138 countries in the 1982 – 1991 period. We neither found positive autocorrelation according to the Durbin "h" statistic nor heteroscedasticity according to plots of variances. Under these conditions, ordinary least squares provides consistent and efficient estimators.

The coefficients of the estimated equation are as follows:

$$\begin{aligned} ARMSIMP(it) = & -32 - 8 \times EA - 214 \times MD + 74 \times [ROW \times CWD] \\ & + 96 \times [EA \times CWD] + 316 \times [MD \times CWD] \\ & + 0.0007 \times [ROW \times ME(it)] + 0.0017 \times [EA \times ME(it)] \\ & + 0.0795 \times [MD \times ME(it)] \\ & + 0.8382 \times [ROW \times ARMSIMP(it-1)] \\ & + 0.8647 \times [EA \times ARMSIMP(it-1)] \\ & + 0.7123 \times [MD \times ARMSIMP(it-1)]. \end{aligned} \quad [\text{Eq. A-6}]$$

Equation A-6 embeds three different regional equations — one for the 16 countries in the Middle East, another for the 18 countries in East Asia, and still another for the 104 countries in the rest of the world.

Middle East

Equation A-7 represents the arms import estimating equation for the Middle East:

$$\begin{aligned} ARMSIMP(it) = & -246 + 316 \times CWD + 0.0795 \times ME(it) \\ & + 0.7123 \times ARMSIMP(it-1). \end{aligned} \quad [\text{Eq. A-7}]$$

By summing Equation A-7 over the 16 countries in the Middle East, we obtain a Middle East regionwide equation, Equation A-8.

$$\begin{aligned} ARMSIMP(t) = & -3936 + 5056 \times CWD + 0.0795 \times ME(t) \\ & + 0.7123 \times ARMSIMP(t-1). \end{aligned} \quad [\text{Eq. A-8}]$$

Equation A-8 provides the Middle East explanatory effects as follows:

- a. Post-cold war tendency= -\$13,681 million of real arms imports
[-3936/(1-0.7123)]
- b. Cold war tendency= \$3,893 million of real arms imports
[(5056-3936)/(1-0.7123)]
- c. Cold war effect= \$17,574 million of real arms imports [difference of (b) minus (a)]
- d. Arms import propensity= 0.0795

We also used Equation A-8 to make projections for Middle East arms imports.

East Asia

Equation A-9 represents the arms import estimating equation for East Asia:

$$ARMSIMP(it) = -40 + 96 \times CWD + 0.0017 \times ME(it) + 0.8647 \times ARMSIMP(it-1). \quad [\text{Eq. A-9}]$$

By summing Equation A-9 over the 18 countries in East Asia, we obtain an East Asia regionwide equation, Equation A-10.

$$ARMSIMP(t) = -720 + 1728 \times CWD + 0.0017 \times ME(t) + 0.8647 \times ARMSIMP(t-1). \quad [\text{Eq. A-10}]$$

Equation A-10 provides the East Asia explanatory effects as follows:

- a. Post-cold war tendency= -\$5,322 million of real arms imports
[-720/(1-0.8647)]
- b. Cold war tendency= \$7,450 million of real arms imports
[(1728-720)/(1-0.8647)]
- c. Cold war effect= \$12,772 million of real arms imports [difference of (b) minus (a)]
- d. Arms import propensity=0.0017

We also used Equation A-10 to make projections for East Asia arms imports.

Rest of the World

Equation A-11 represents the arms imports estimating equation for the rest of the world:

$$ARMSIMP(it) = -32 + 74 \times CWD + 0.0007 \times ME(it) + 0.8382 \times ARMSIMP(it-1). \quad [\text{Eq. A-11}]$$

By summing Equation A-11 over the 104 countries in the rest of the world, we obtain a rest-of-the-world equation, Equation A-12.

$$ARMSIMP(t) = -3328 + 7696 \times CWD + 0.0007 \times ME(t) + 0.8382 \times ARMSIMP(t-1). \quad [\text{Eq. A-12}]$$

Equation A-12 provides the rest-of-the-world explanatory effects as follows:

- a. Post-cold war tendency=-\$20,569 million of real arms imports $[-3328/(1-0.8382)]$
- b. Cold war tendency= \$26,996 million of real arms imports $[(7696-3328)/(1-0.8382)]$
- c. Cold war effect= \$47,565 million of real arms imports [difference of (b) minus (a)]
- d. Arms import propensity=0.0007

We also used equation A-12 to make projections for rest-of-the-world arms imports.